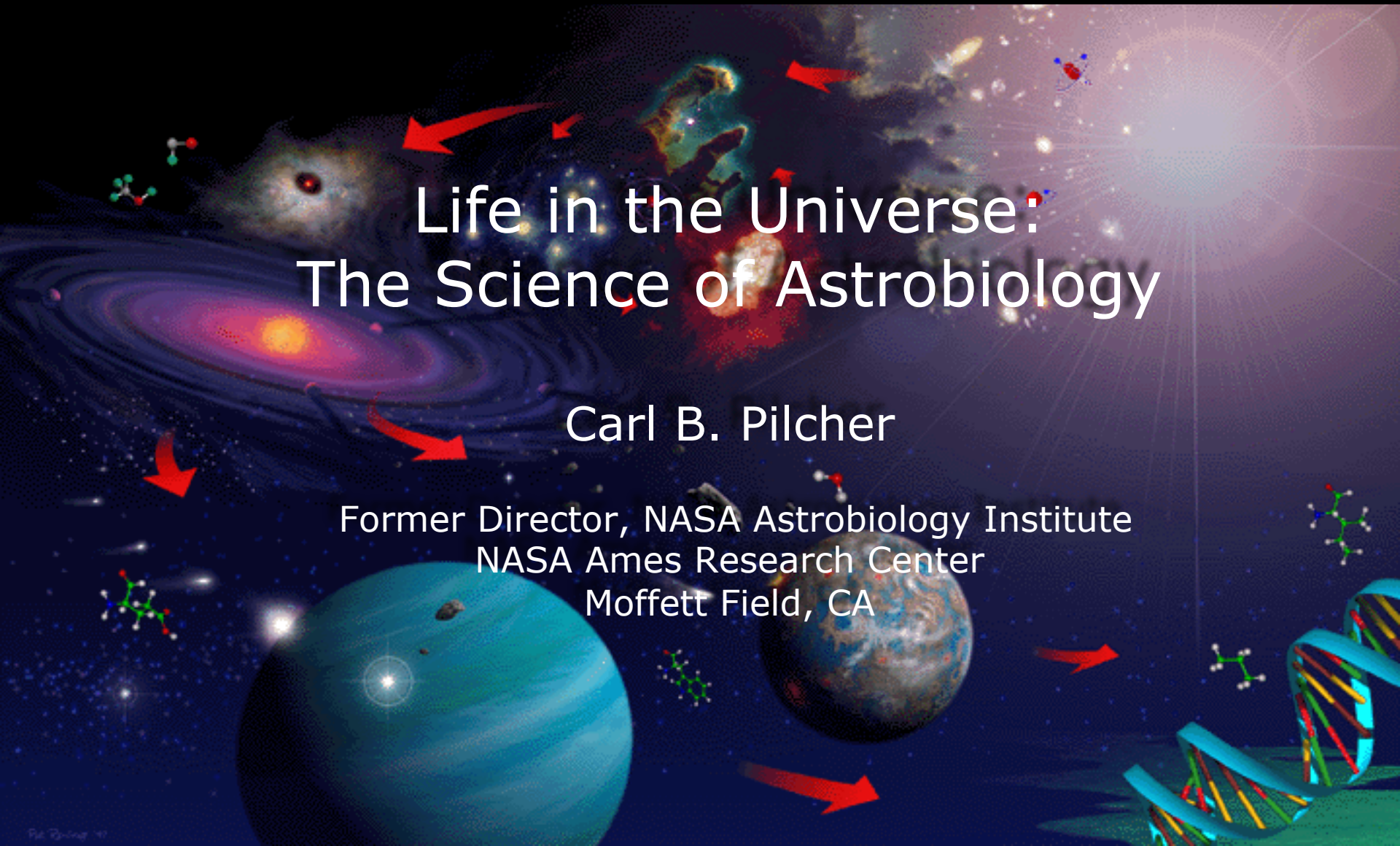
Solar System Ambassadors+

August 22, 2016

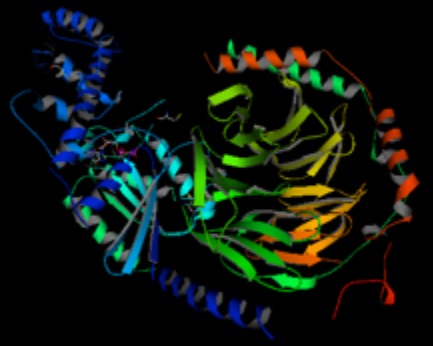


Life in the Universe: The Science of Astrobiology

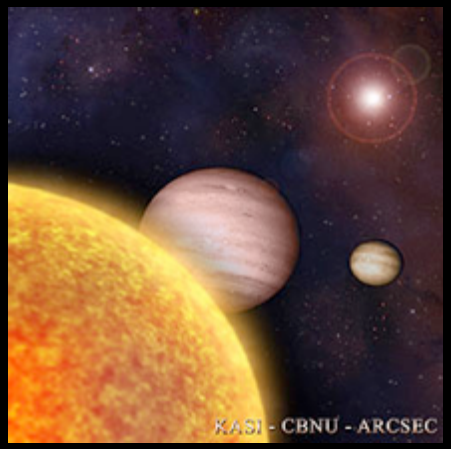
Carl B. Pilcher

Former Director, NASA Astrobiology Institute
NASA Ames Research Center
Moffett Field, CA

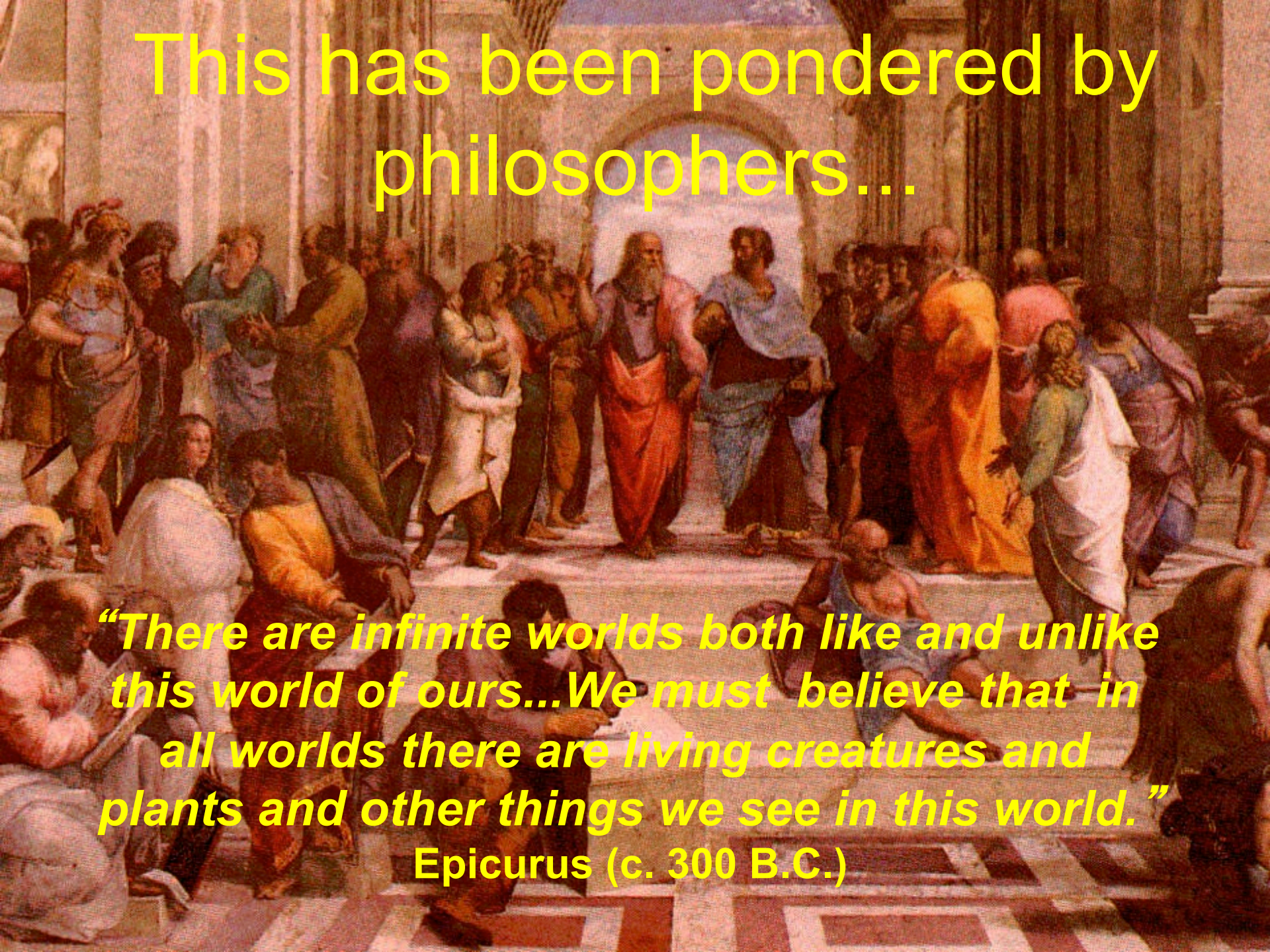
What is Astrobiology?



Study of the potential of the Universe to harbor life beyond Earth



This has been pondered by philosophers...



"There are infinite worlds both like and unlike this world of ours...We must believe that in all worlds there are living creatures and plants and other things we see in this world."

Epicurus (c. 300 B.C.)

…and theologians

St. Thomas Aquinas (13th Cent.)

"When it is said…that many worlds are better than one, … this sort of better…does not belong to the intention of God…because for the same reason it could be said that if he made two, it would be better that there were three; and thus ad infinitum."

Today astrobiology addresses three fundamental scientific questions

- How does life begin and evolve?

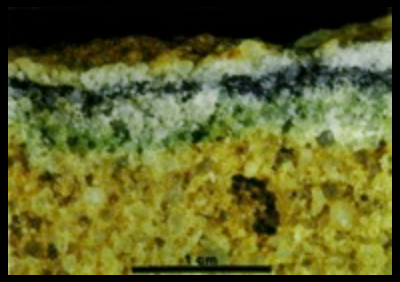
- Does life exist elsewhere in the universe?

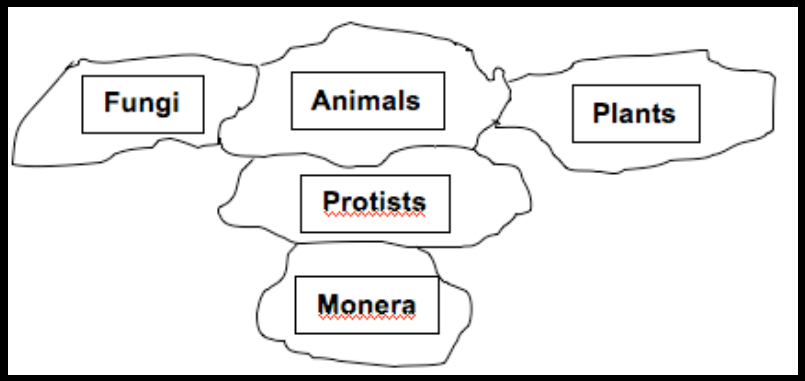
- What is the future of life on Earth and beyond?

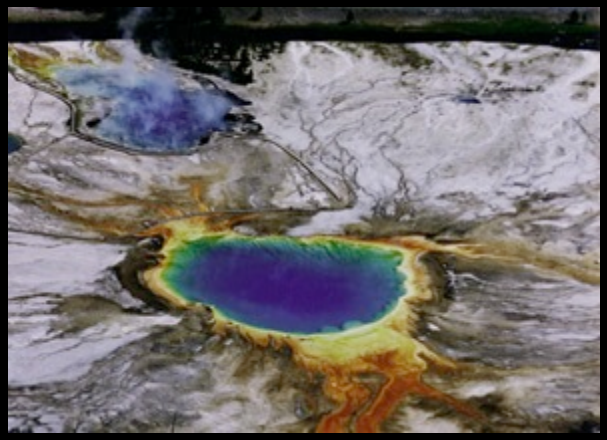
Five Interconnected Areas of Science

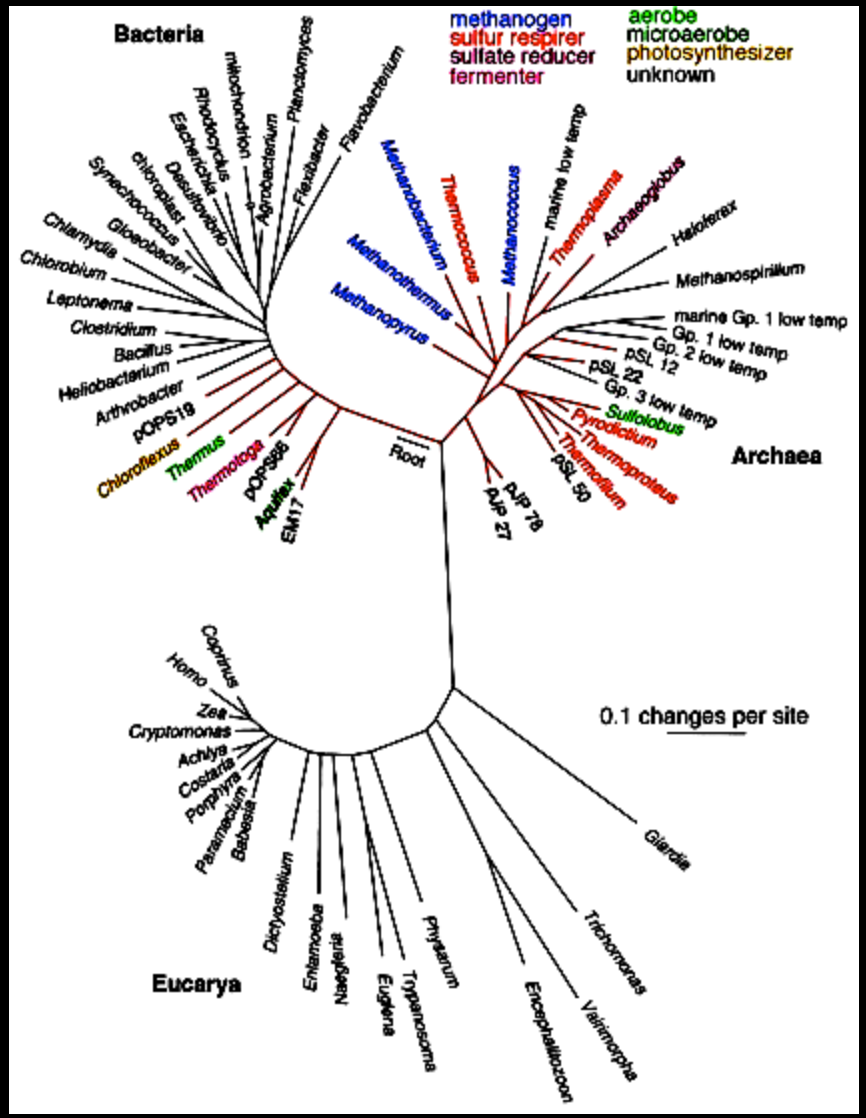
1. Diversity of life on modern Earth
2. The co-evolution of life and our planet
3. Diversity of Solar System environments
4. Planetary environments around other stars
5. The origin of life
    a. Where and how the raw ingredients for life are made
    b. How a world may transform from non-living to living

1. The Diversity of Life on Earth

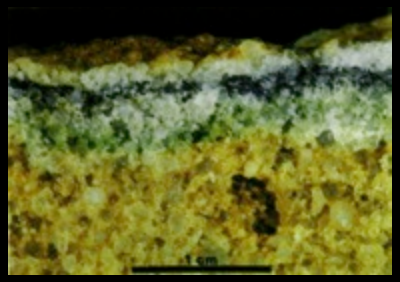


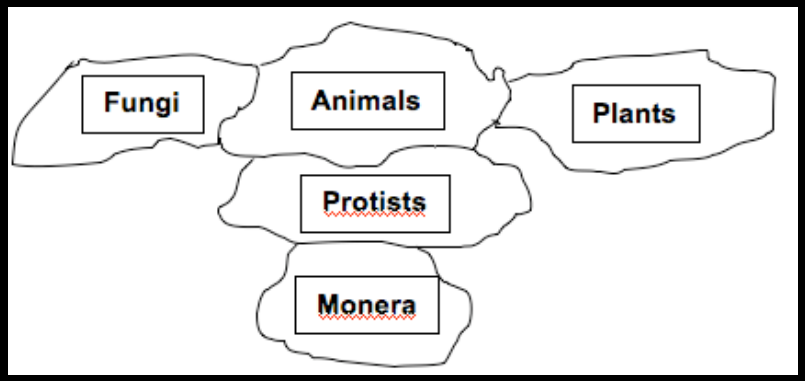


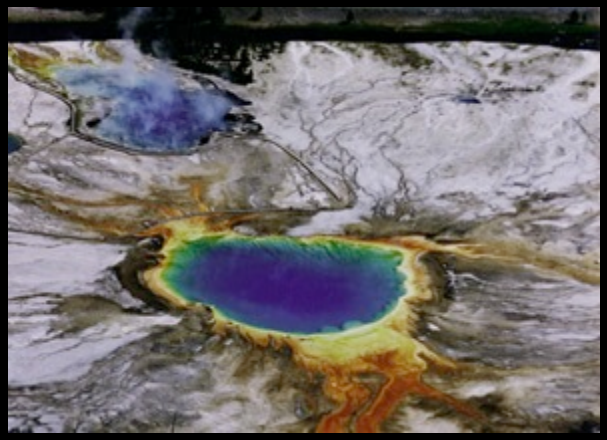


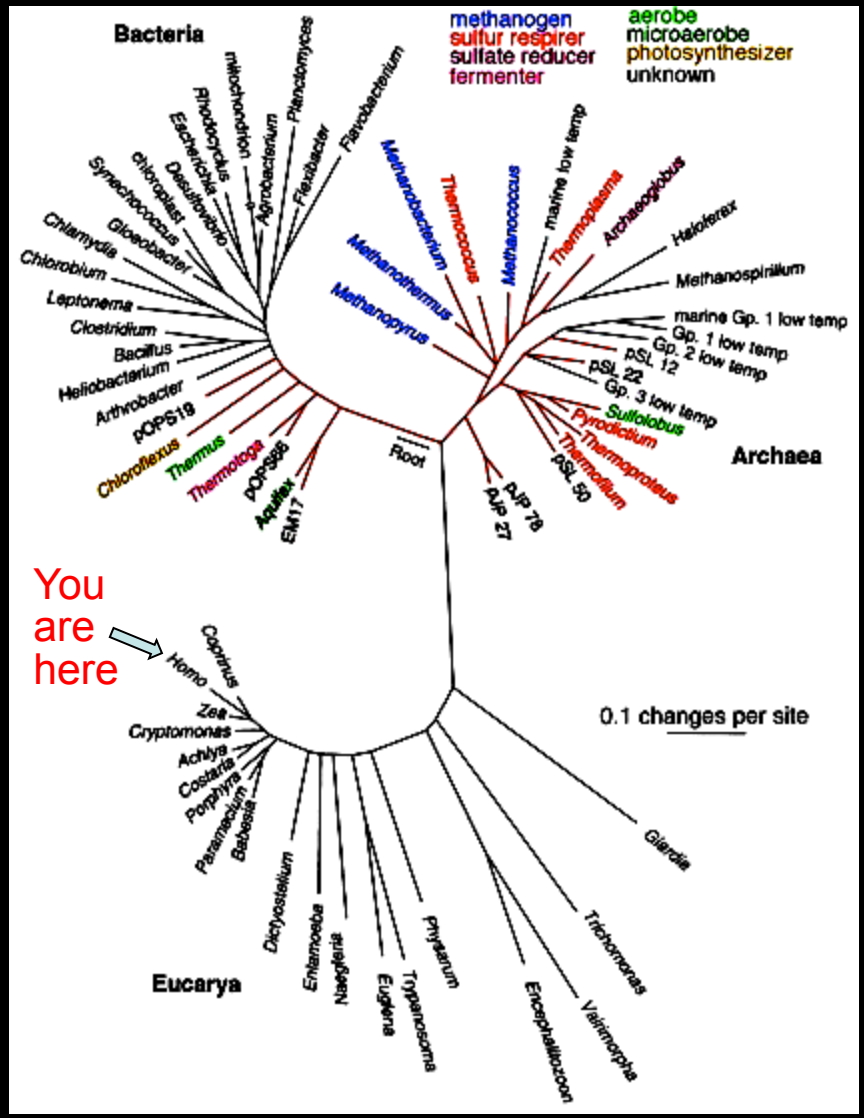


1. The Diversity of Life on Earth

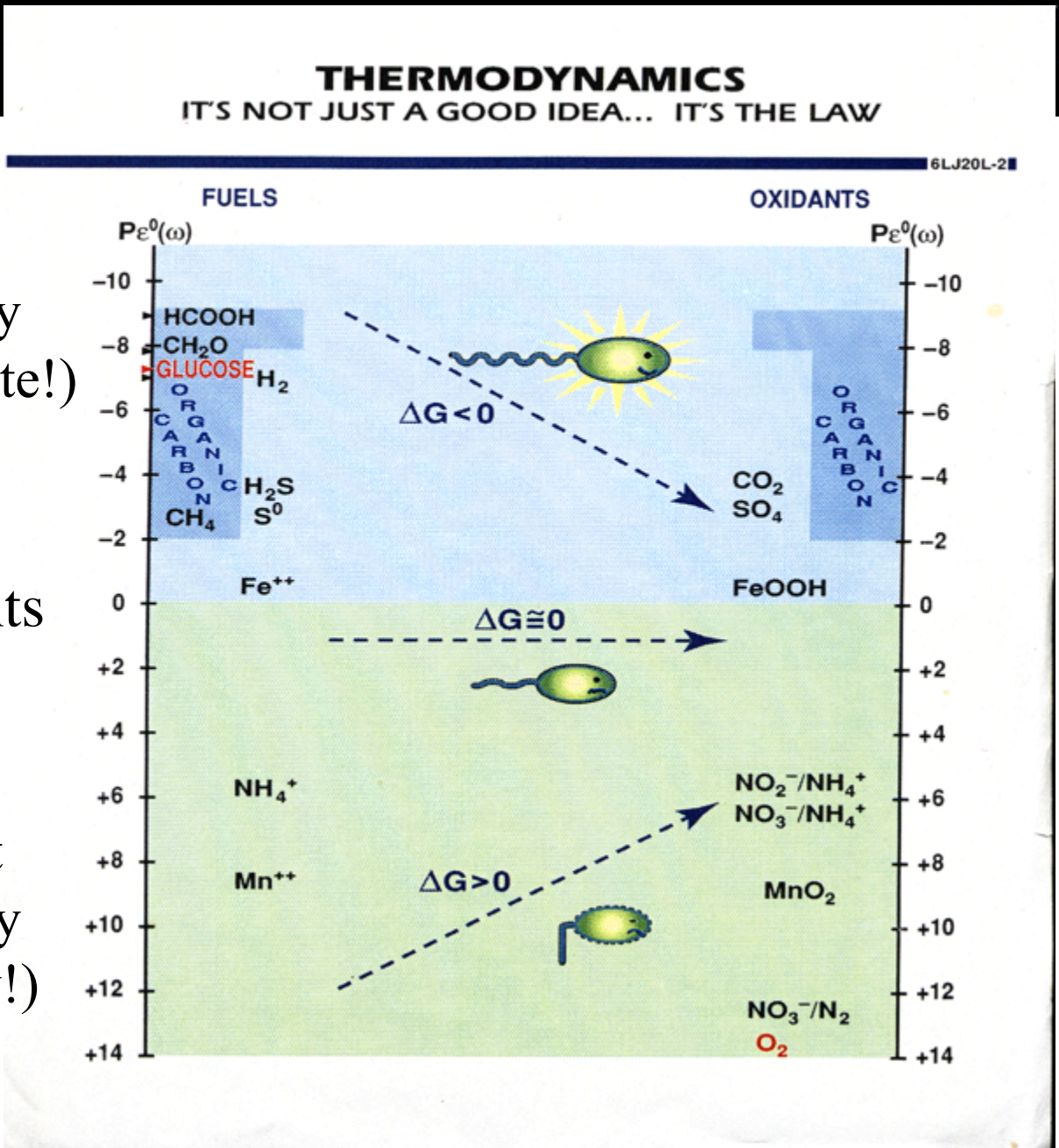








Metabolic Diversity



Most Energy (chocolate!)

Reductants

Least Energy (celery!)

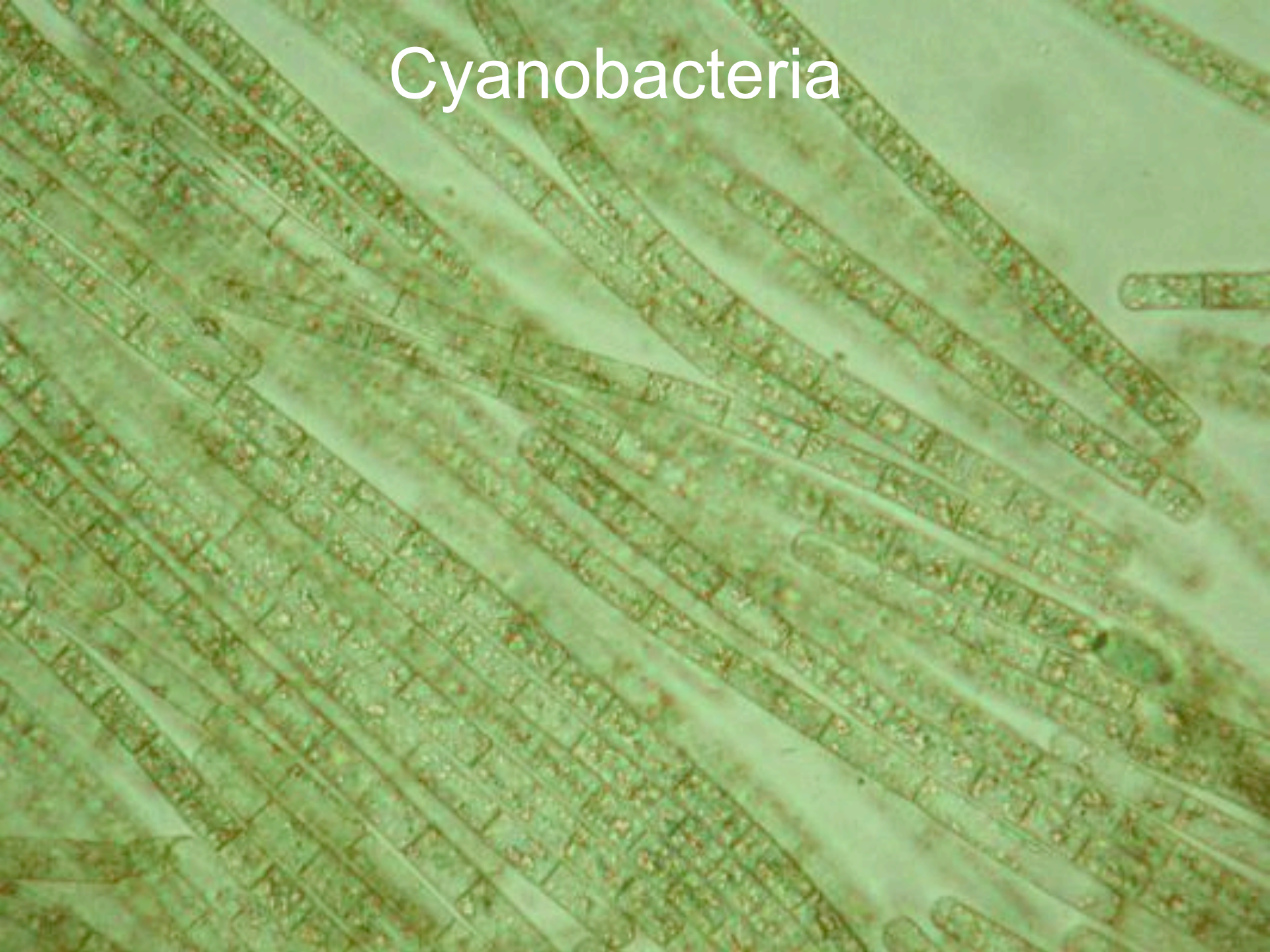
Worst Oxidant

Best Oxidant

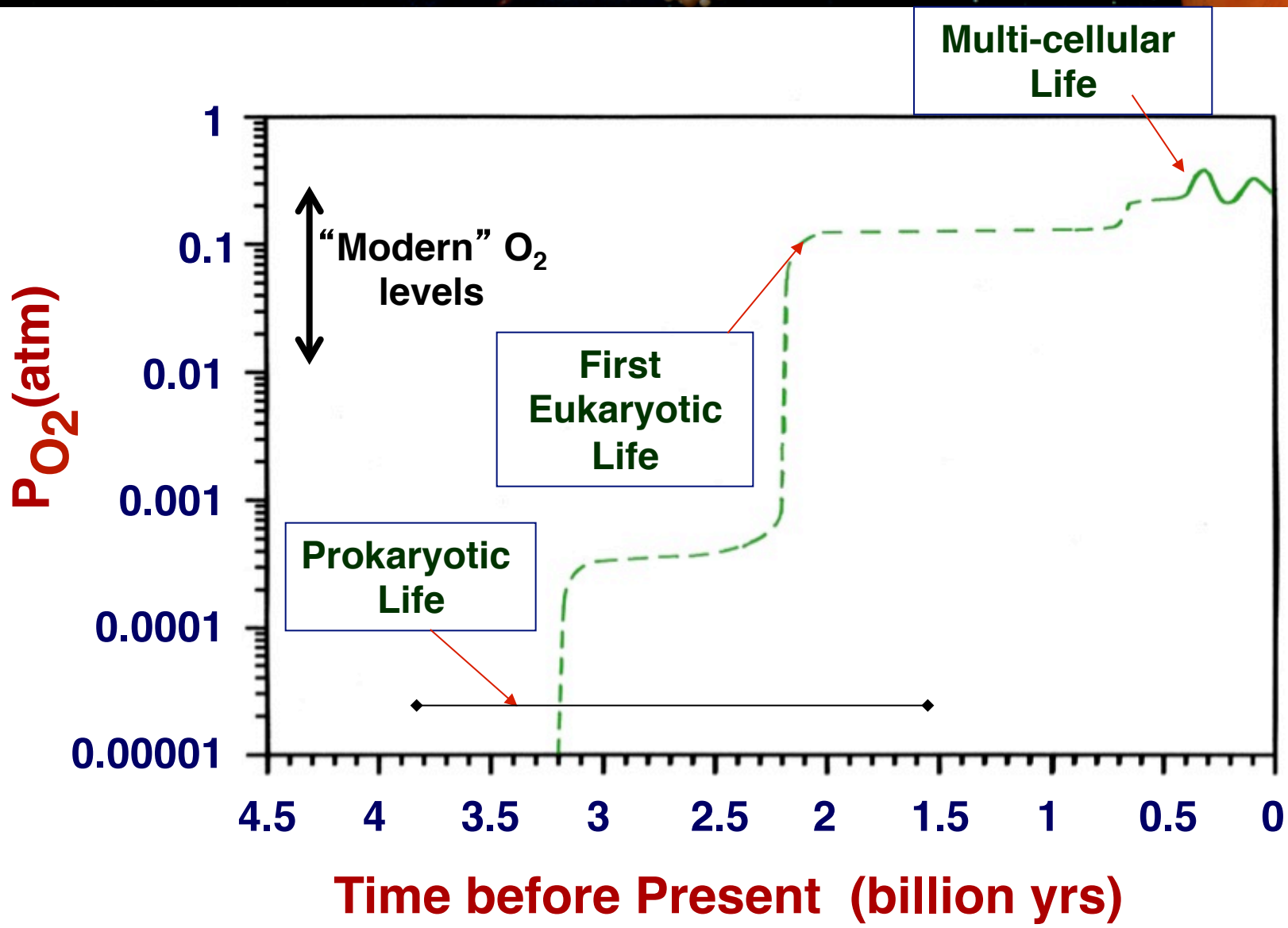
2. Co-evolution of life and the Earth

Stromatolites: Ancient and modern

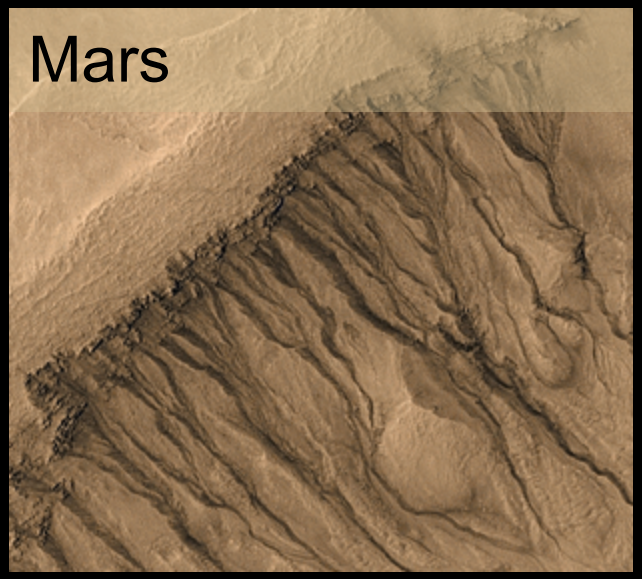
Cyanobacteria

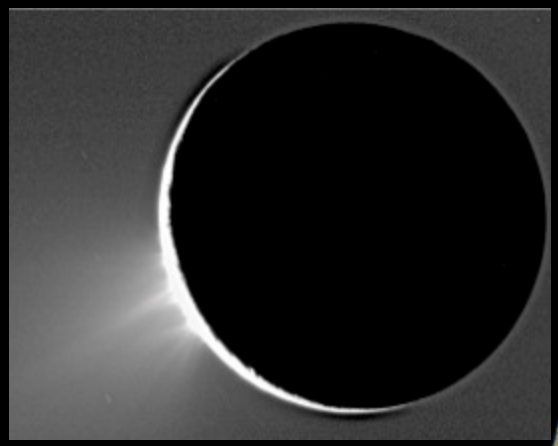


History of Oxygen

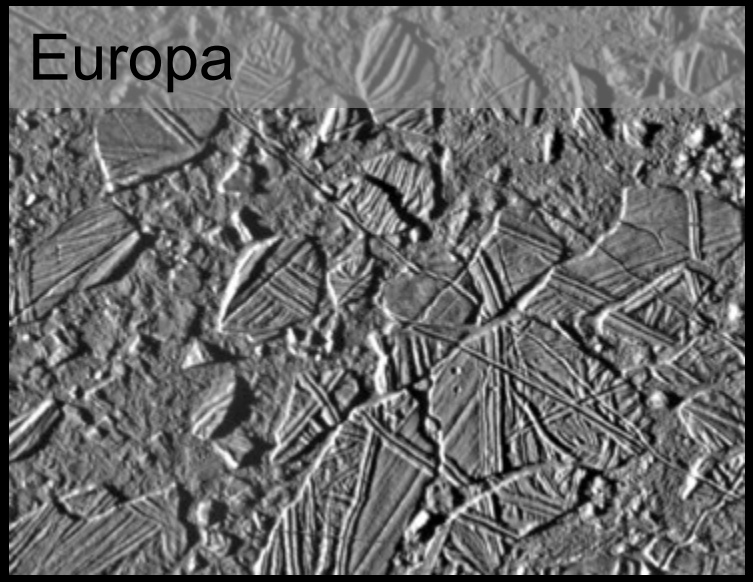


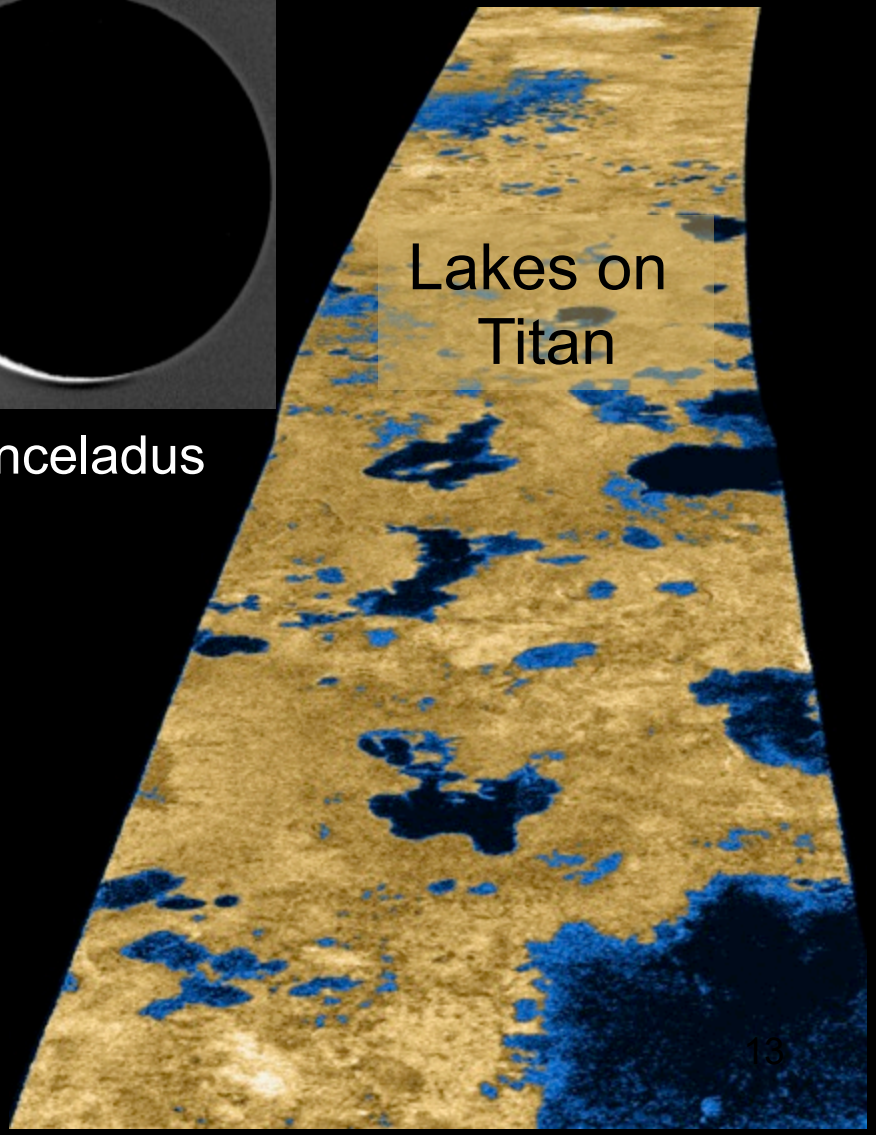
3. The Diversity of Solar System Environments



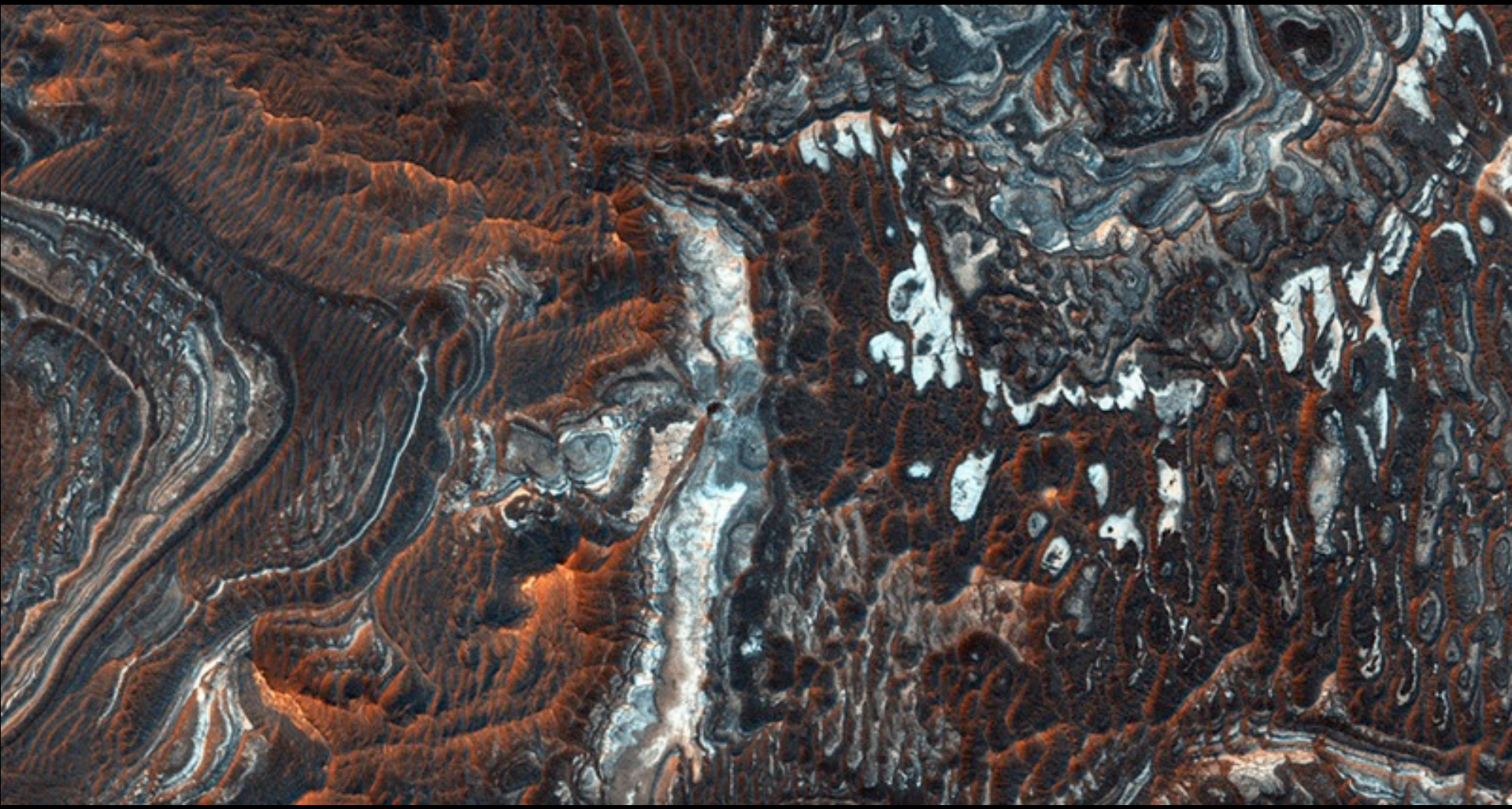


Jets on Enceladus

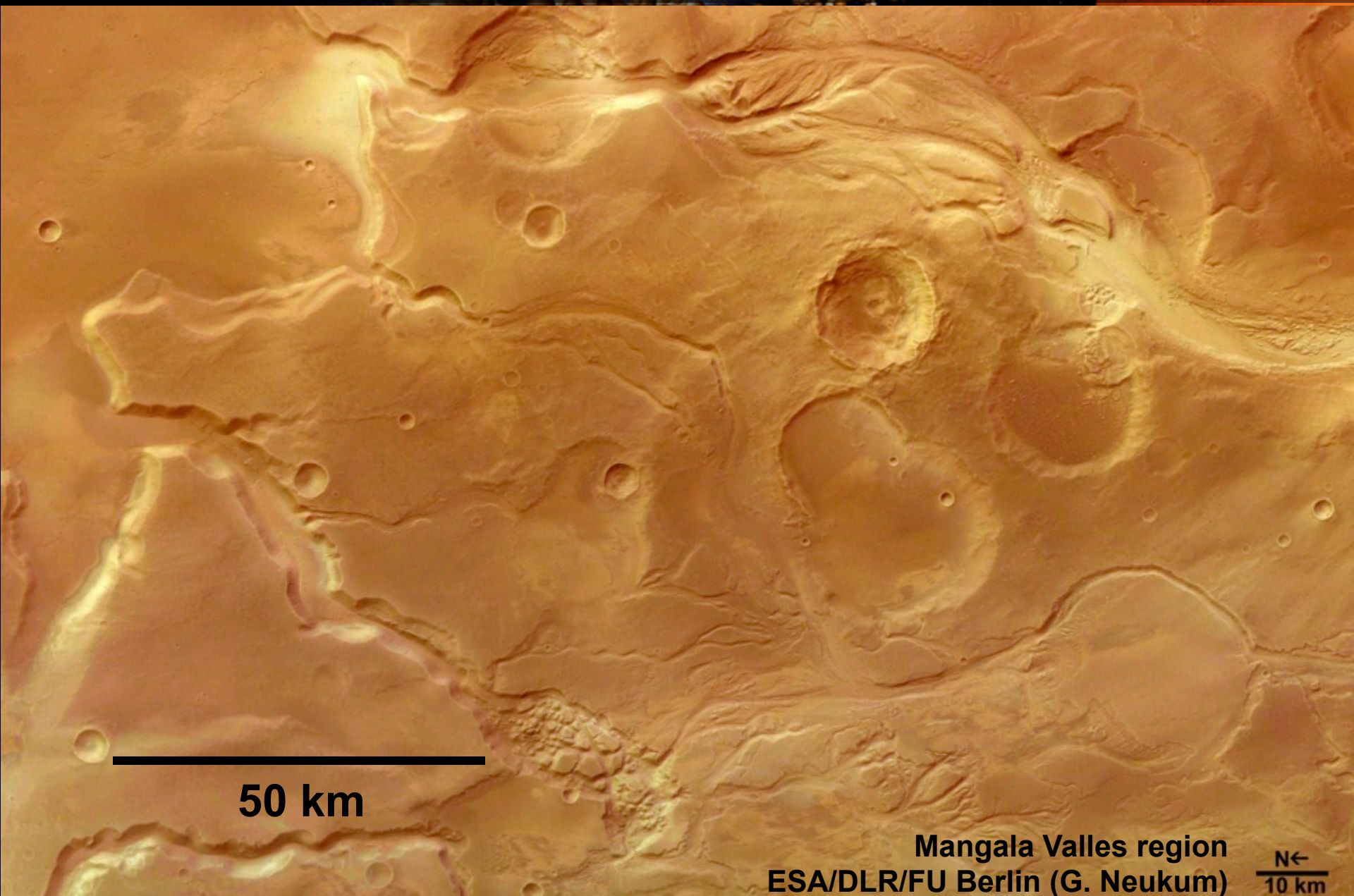




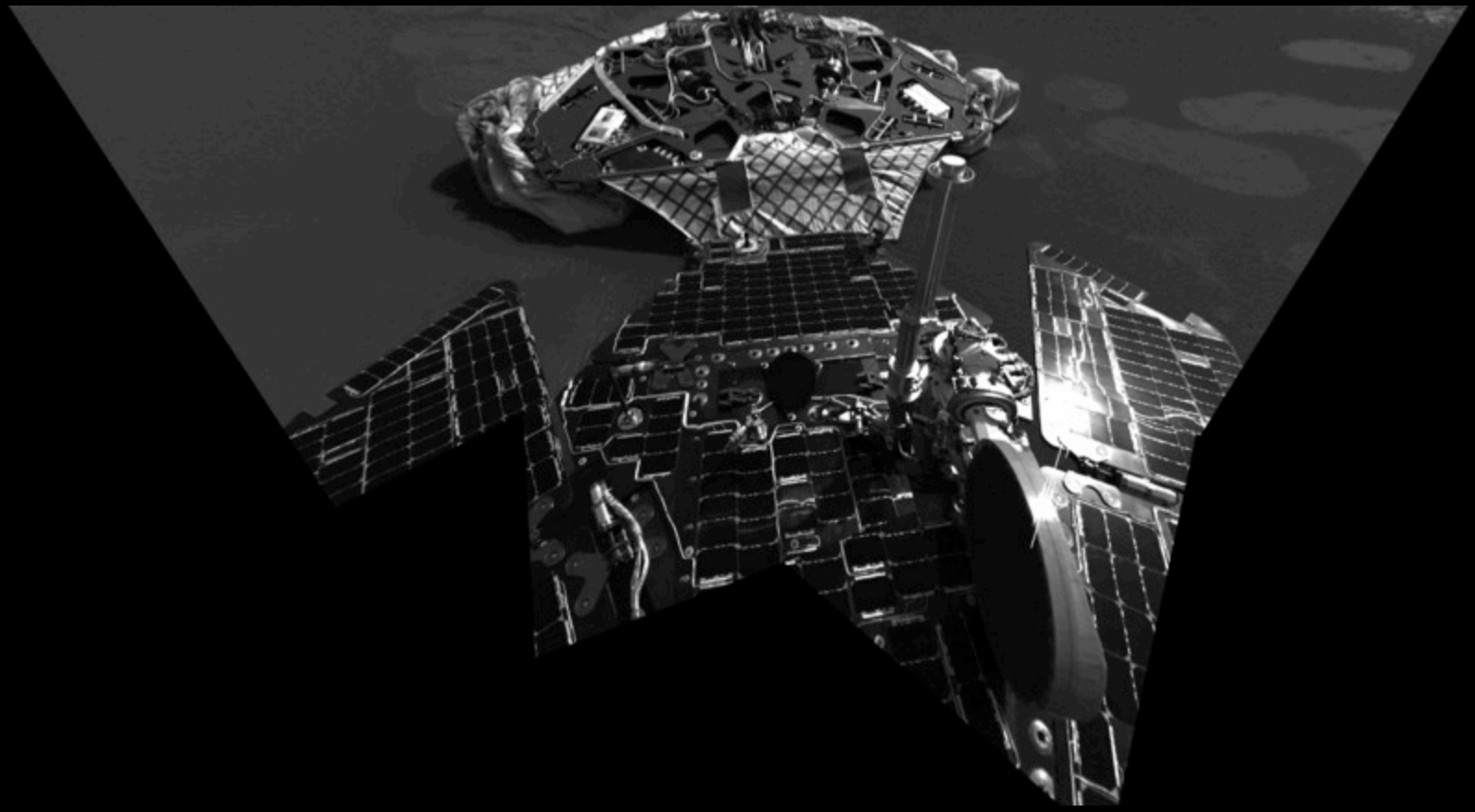
Mars – Juventae Chasma



Enormous dry river systems indicate that large volumes of water flowed across Mars billions of years ago



Opportunity Rover Lands on Mars (2004)

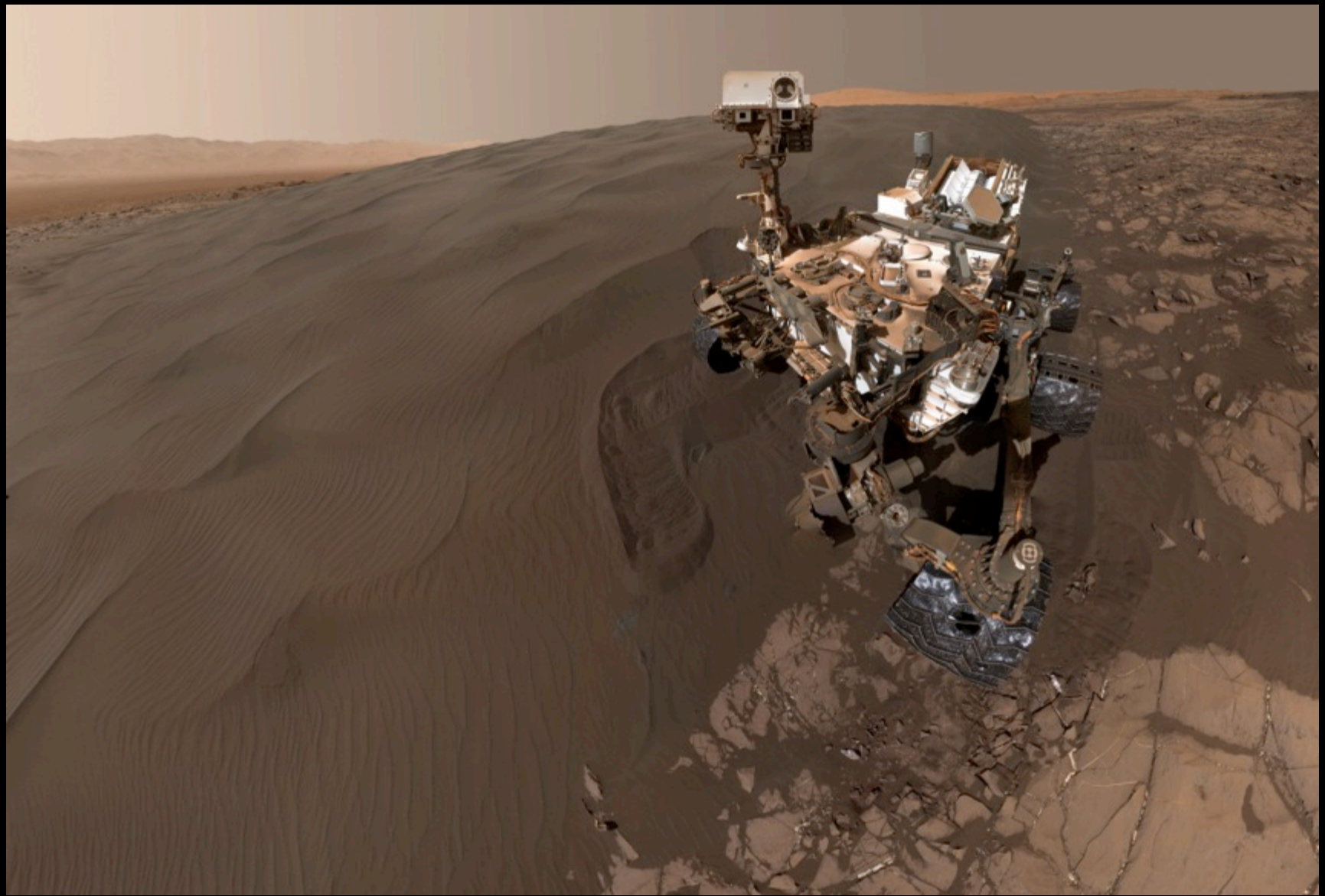


“Blueberry Bowl” (enhanced color)

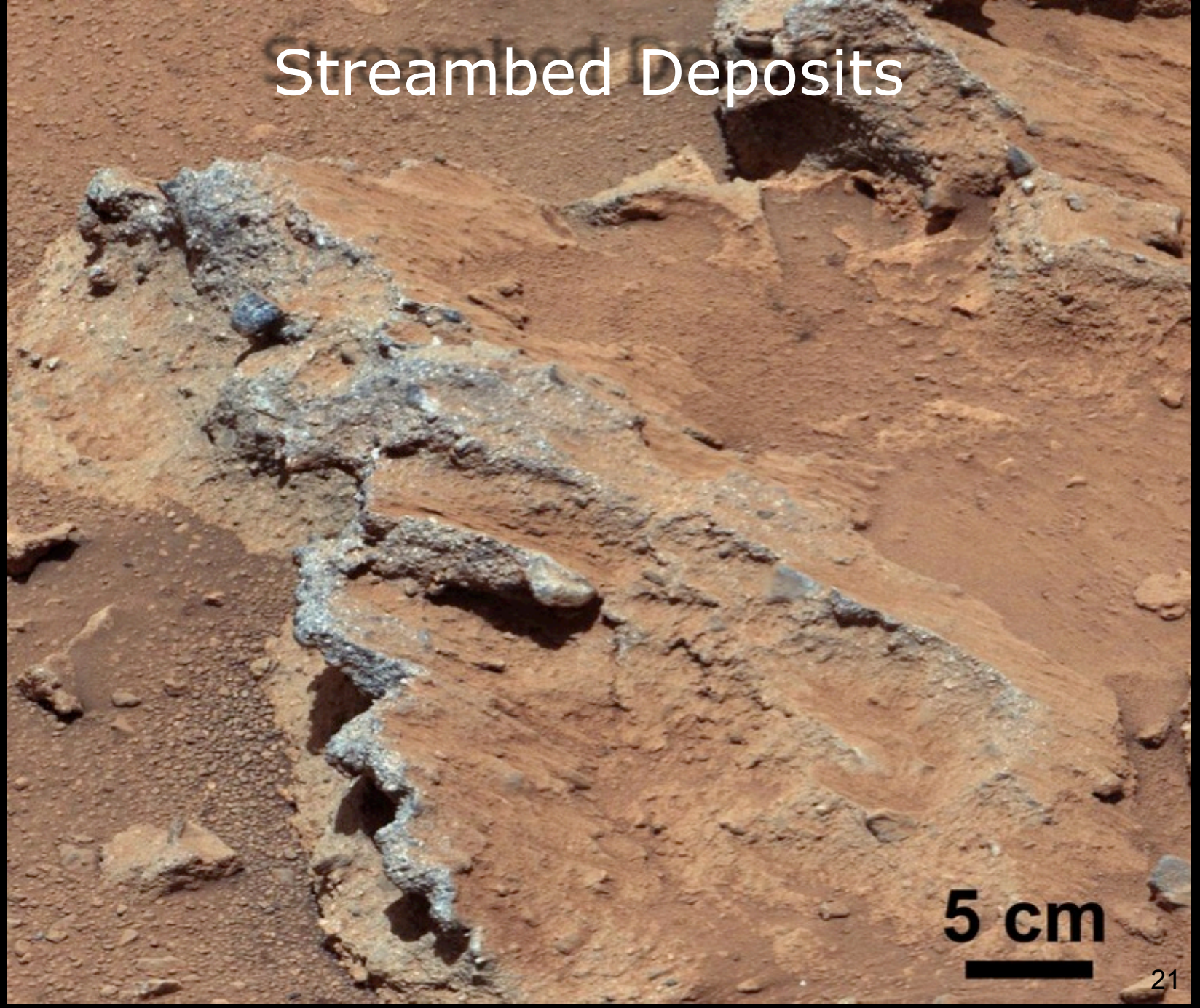
Ice under Phoenix Lander

Liquid (saline) droplets on Phoenix lander strut

Curiosity “Selfie” (2016)

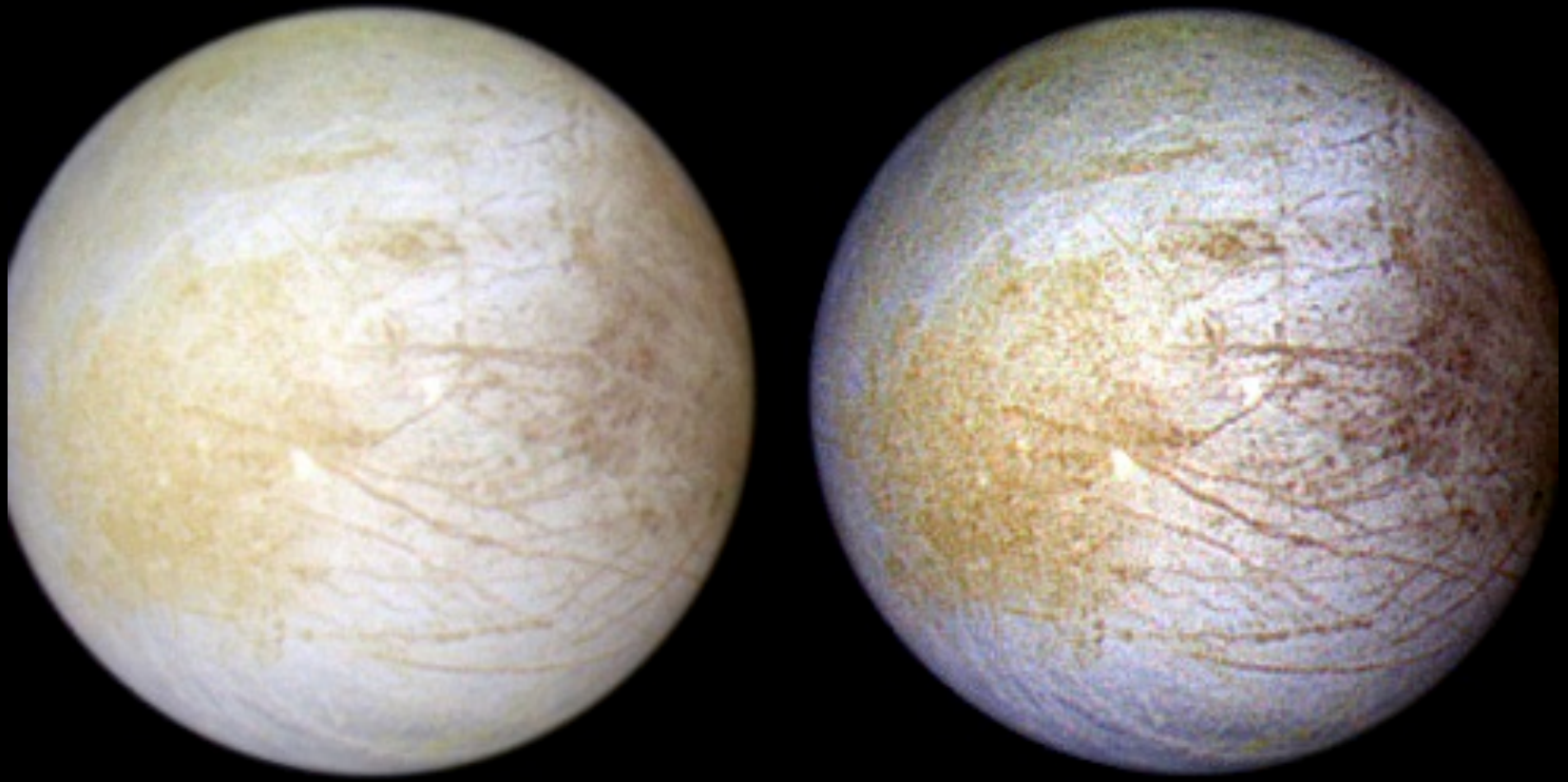


Streambed Deposits

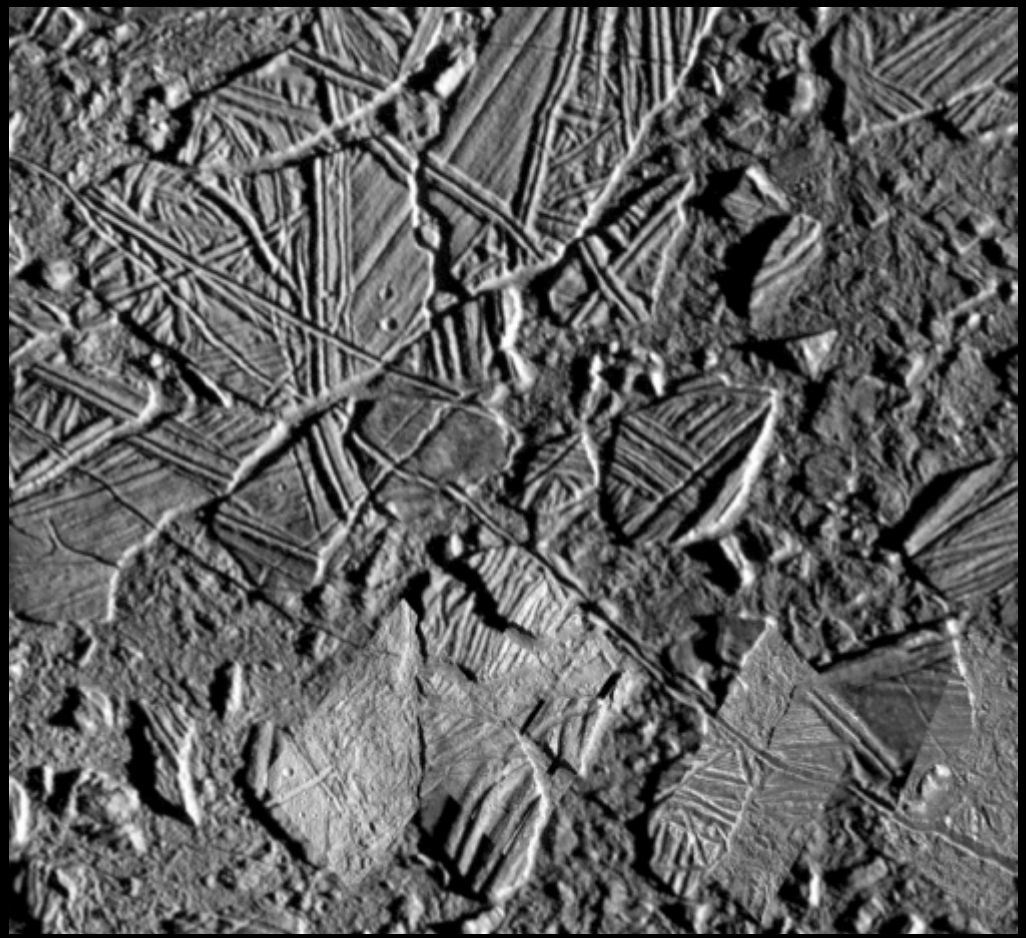


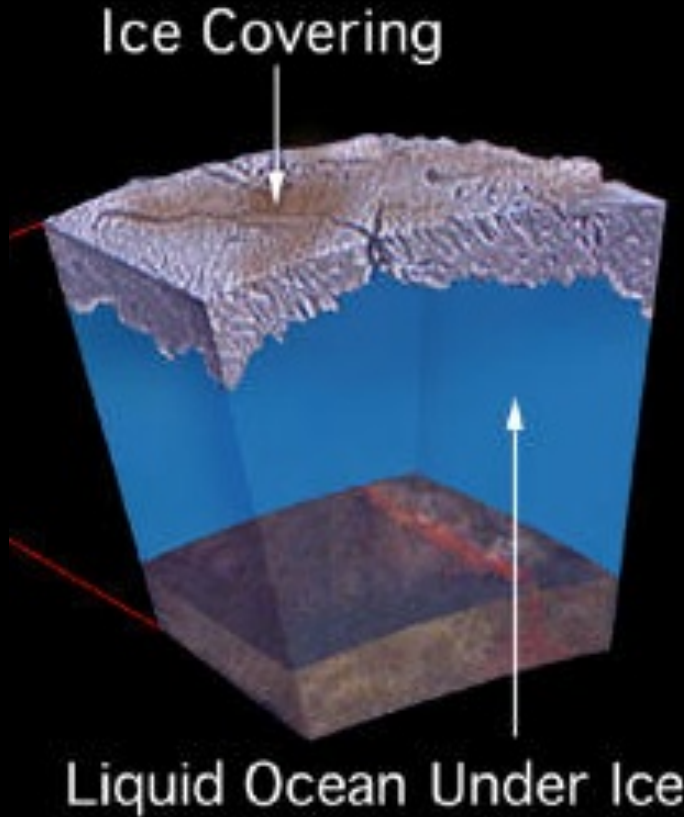
Mt. Sharp Foothills

Europa (moon of Jupiter)



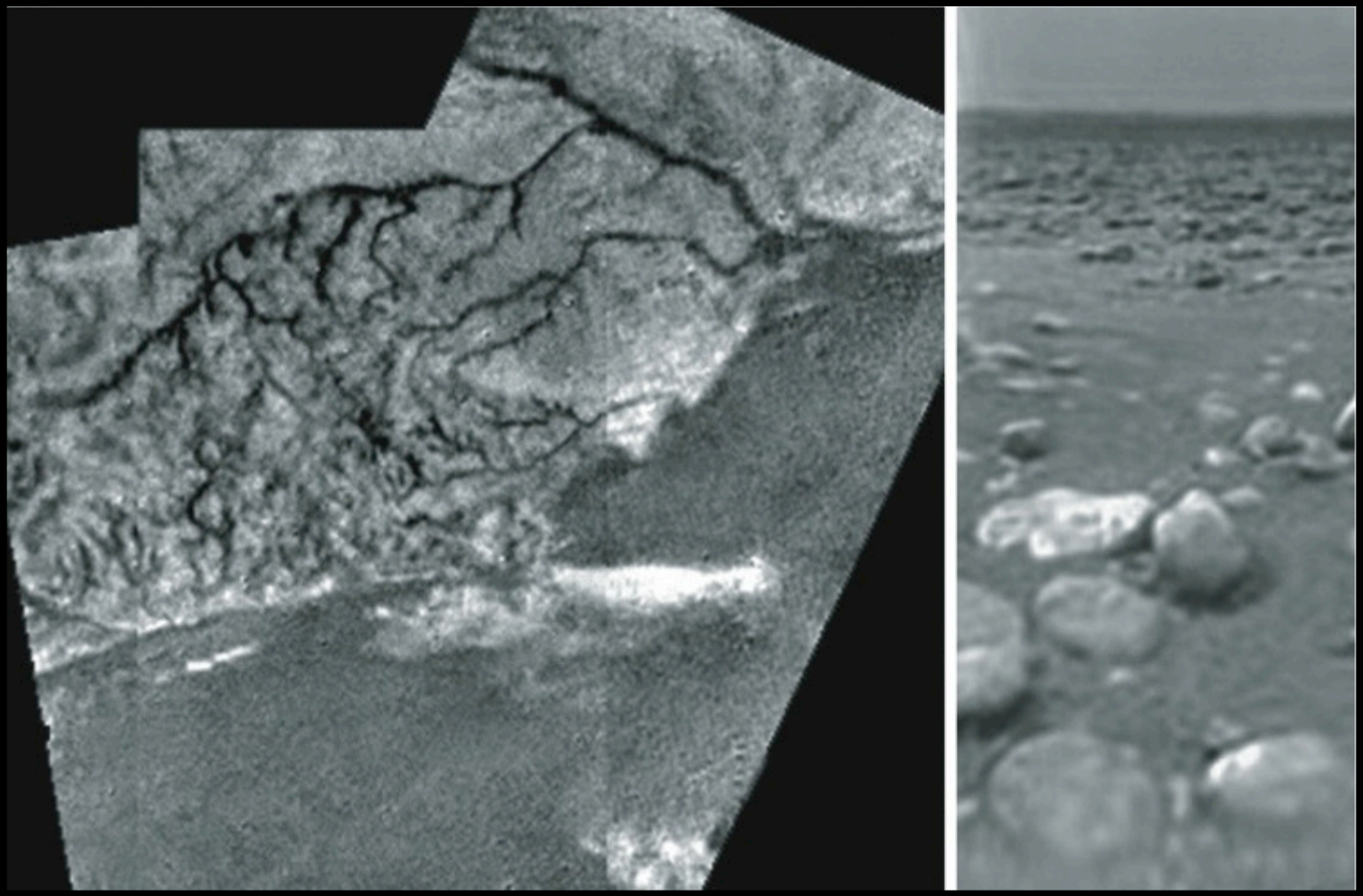
Europa



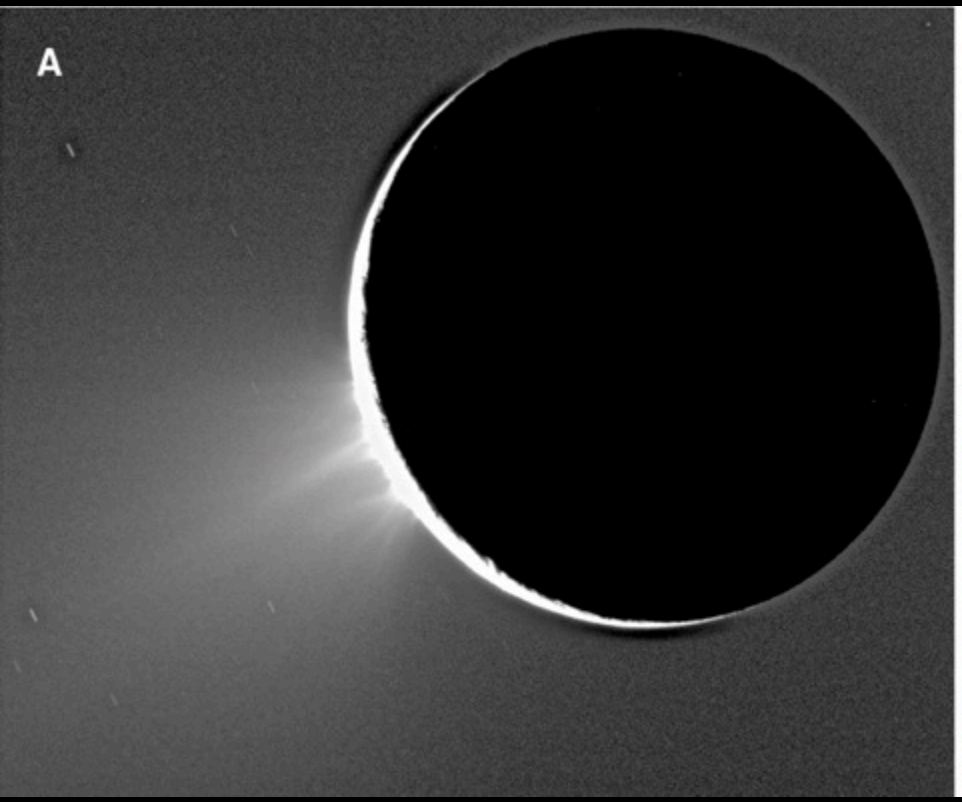


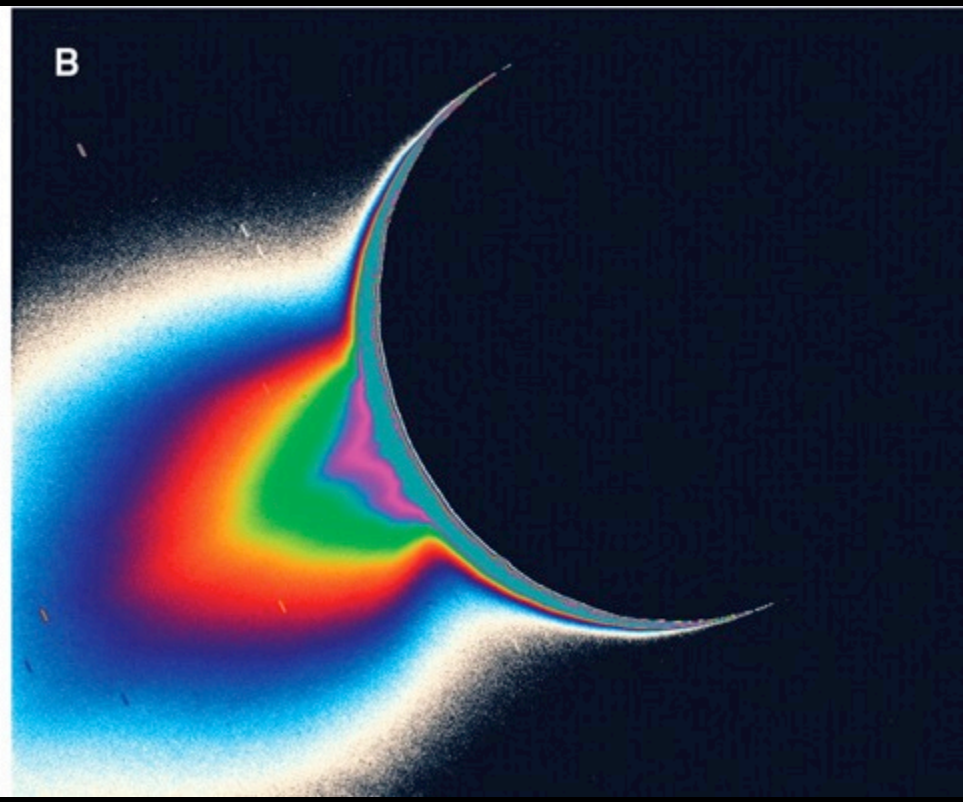
Titan (moon of Saturn)

A Hidden World



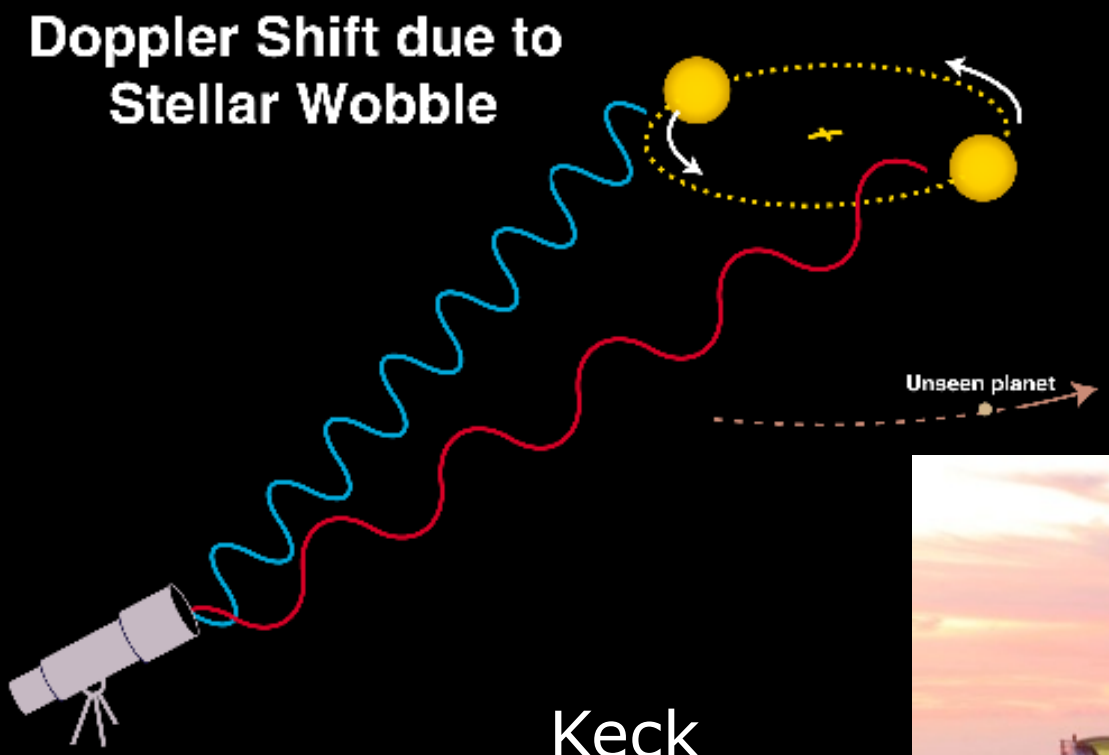
Jets of H_2O (+salts, organics) on Enceladus

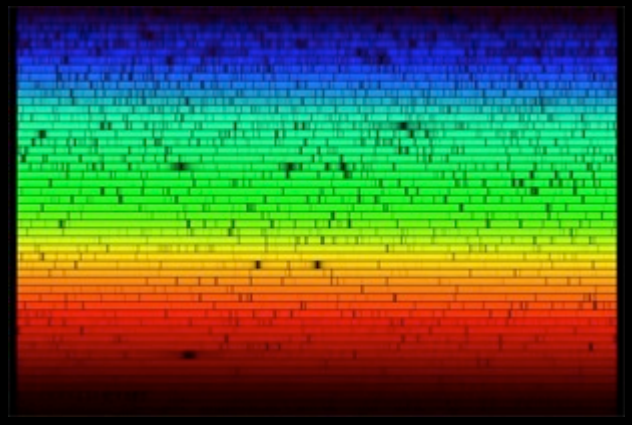




4. Planets Around Other Stars

Doppler Method

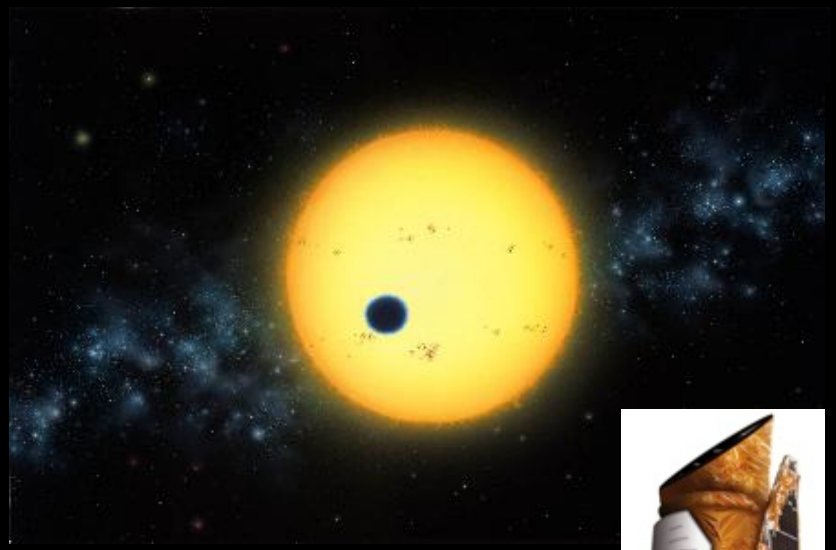


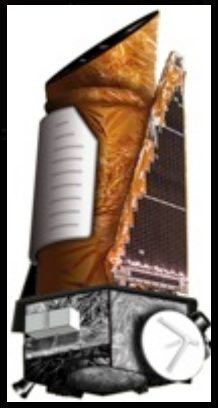


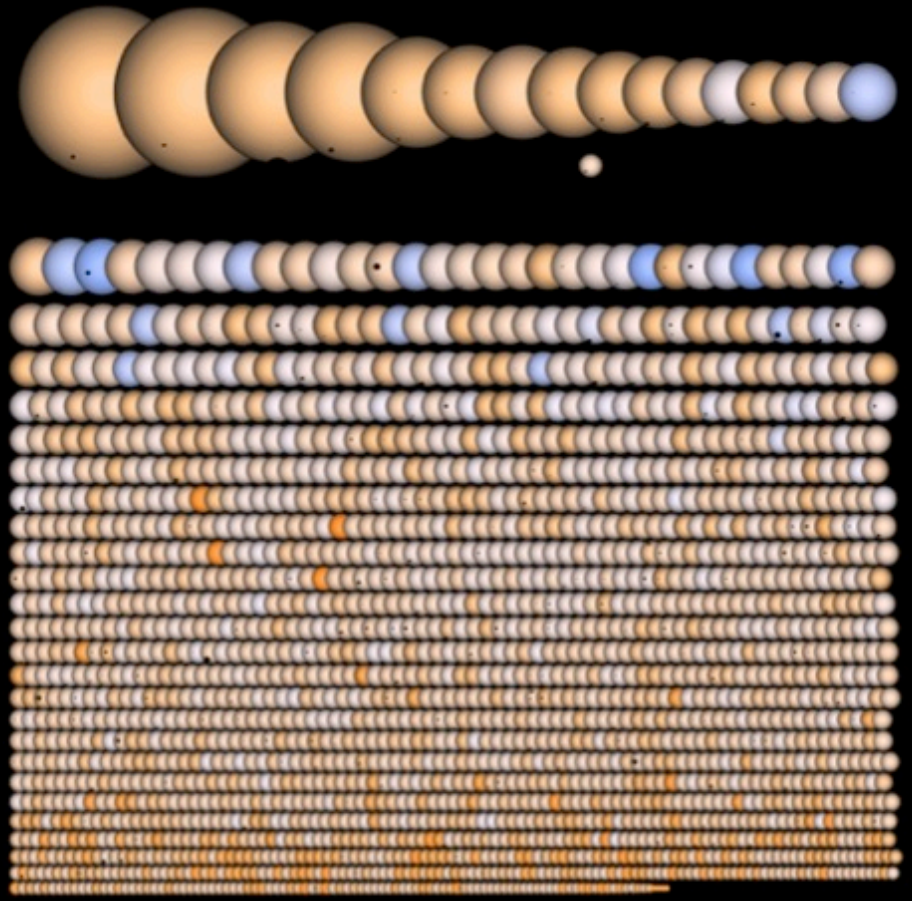
Keck Observatory Mauna Kea, Hawai'i

4. Planets Around Other Stars

Transit Method

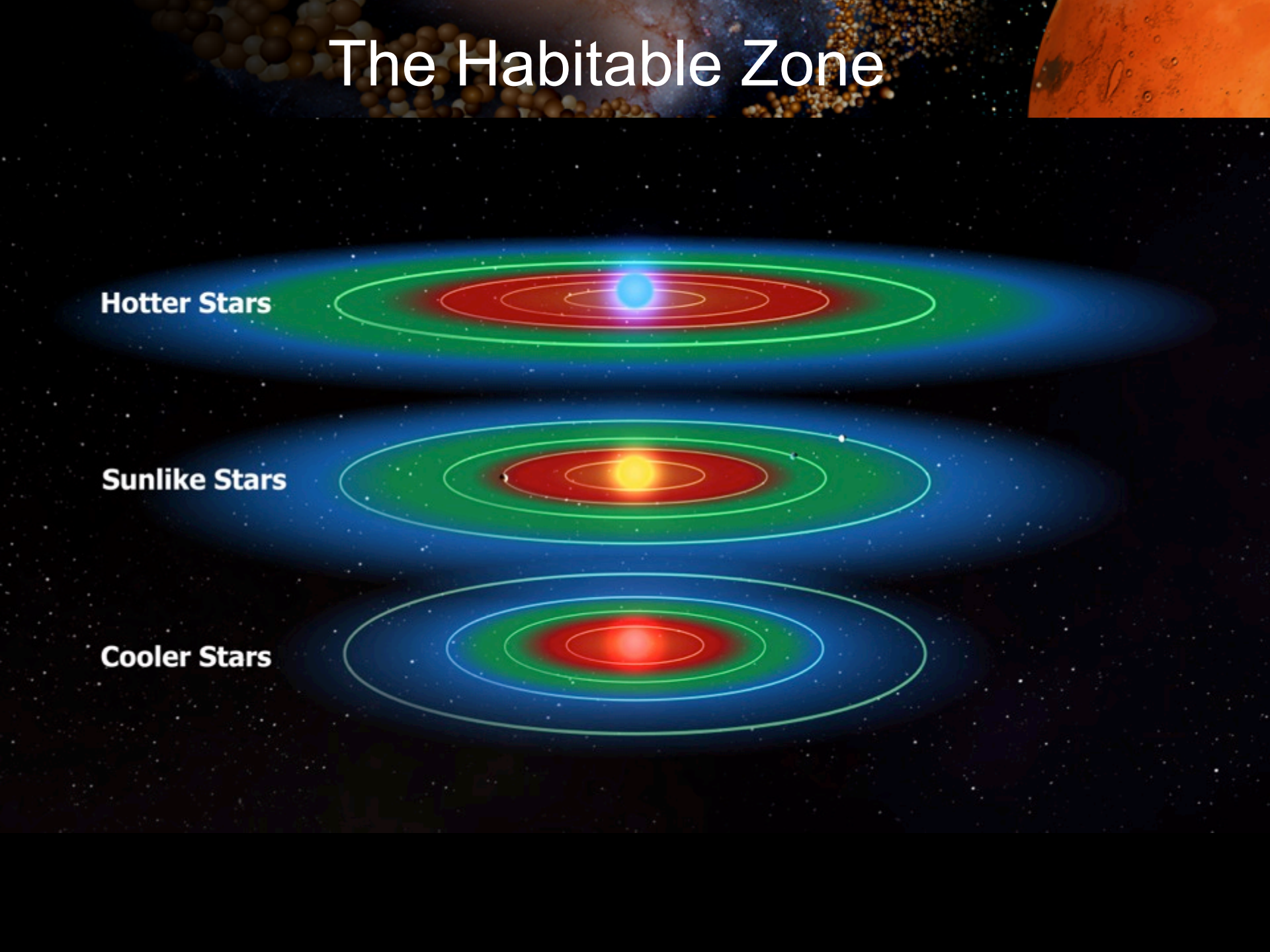






Kepler Planet Candidates

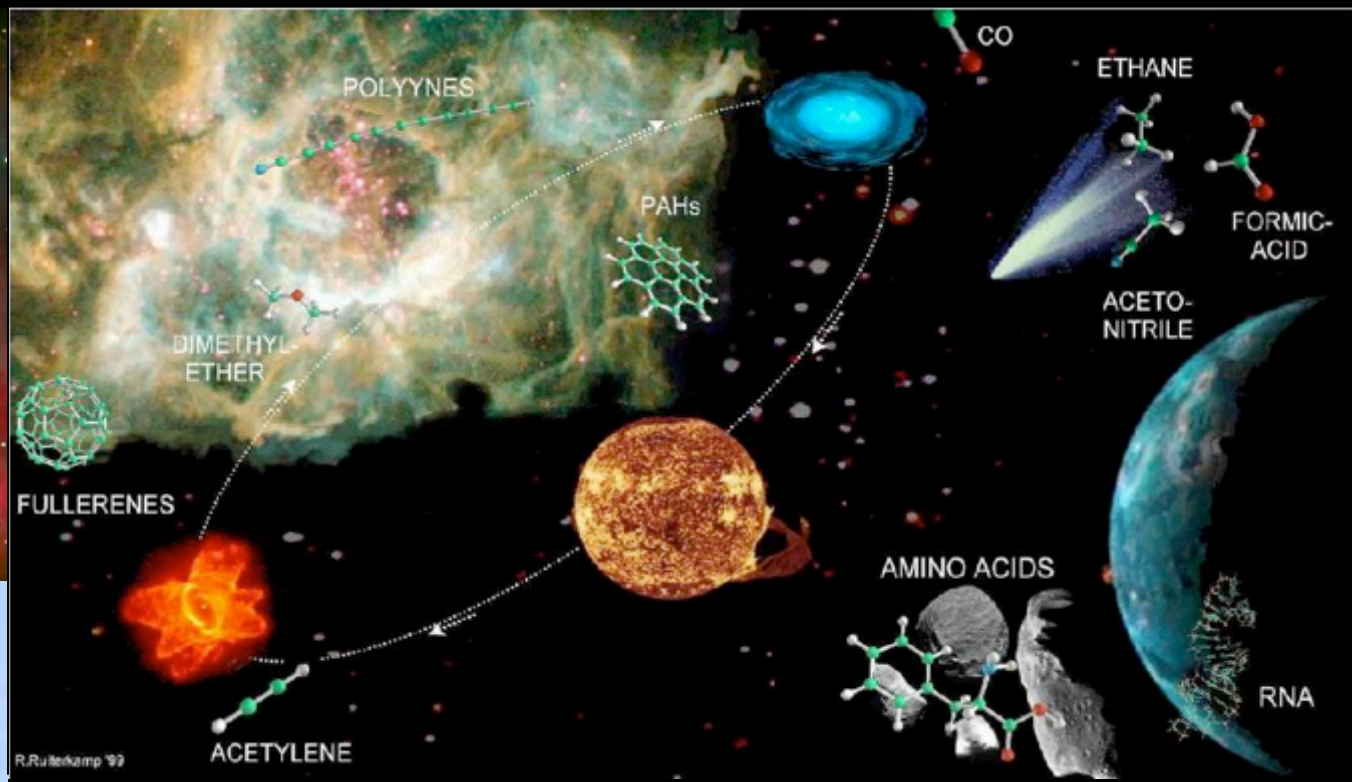
The Habitable Zone



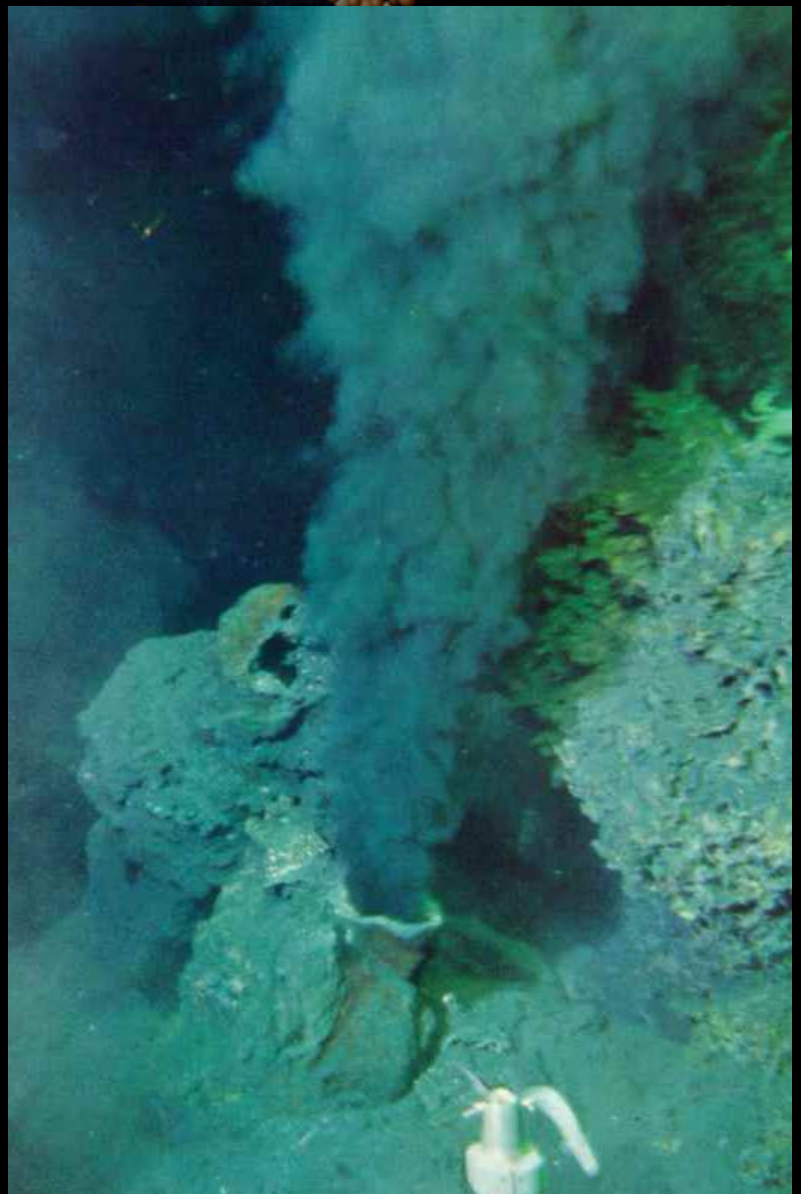
22 ± 8 % of Sun-like stars harbor an Earth-size planet in Habitable Zone

5. Origin of Life

Raw materials from space?



Could Life Have Arisen at a Hydrothermal Vent?

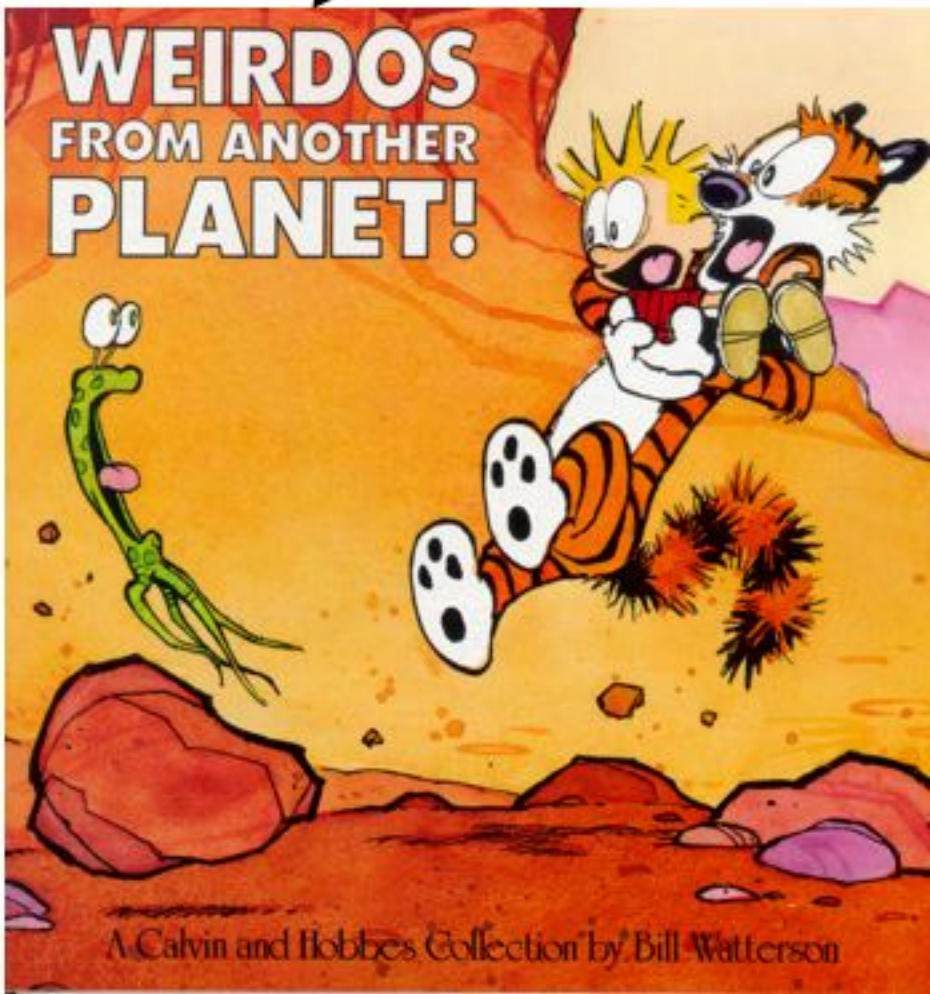


Or in a tide pool?

How do we recognize alien life?

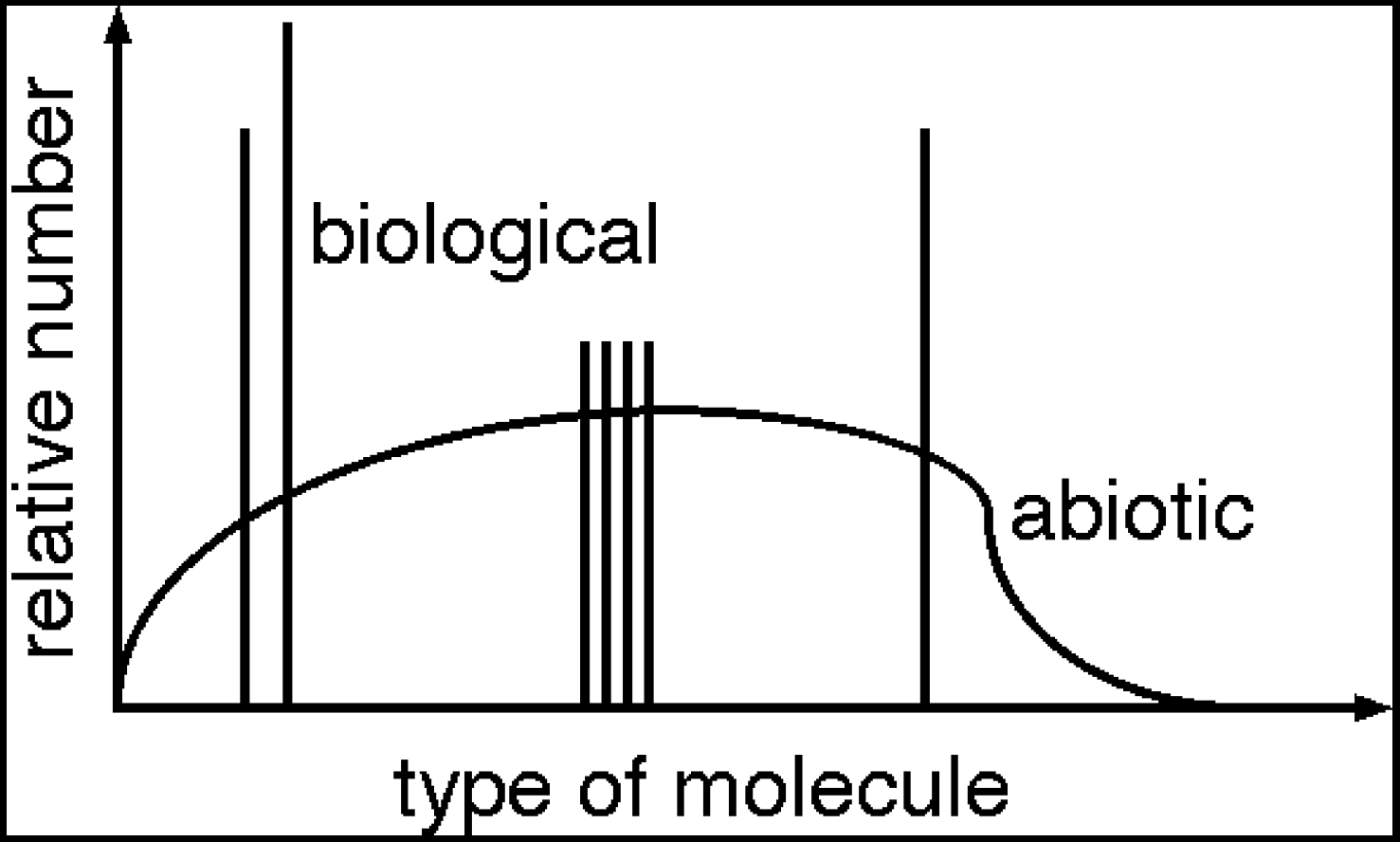
use a tricorder!

we'll know it when we see it!



Slide courtesy C. McKay

Abiotic distributions are smooth
Biotic distributions are spiked



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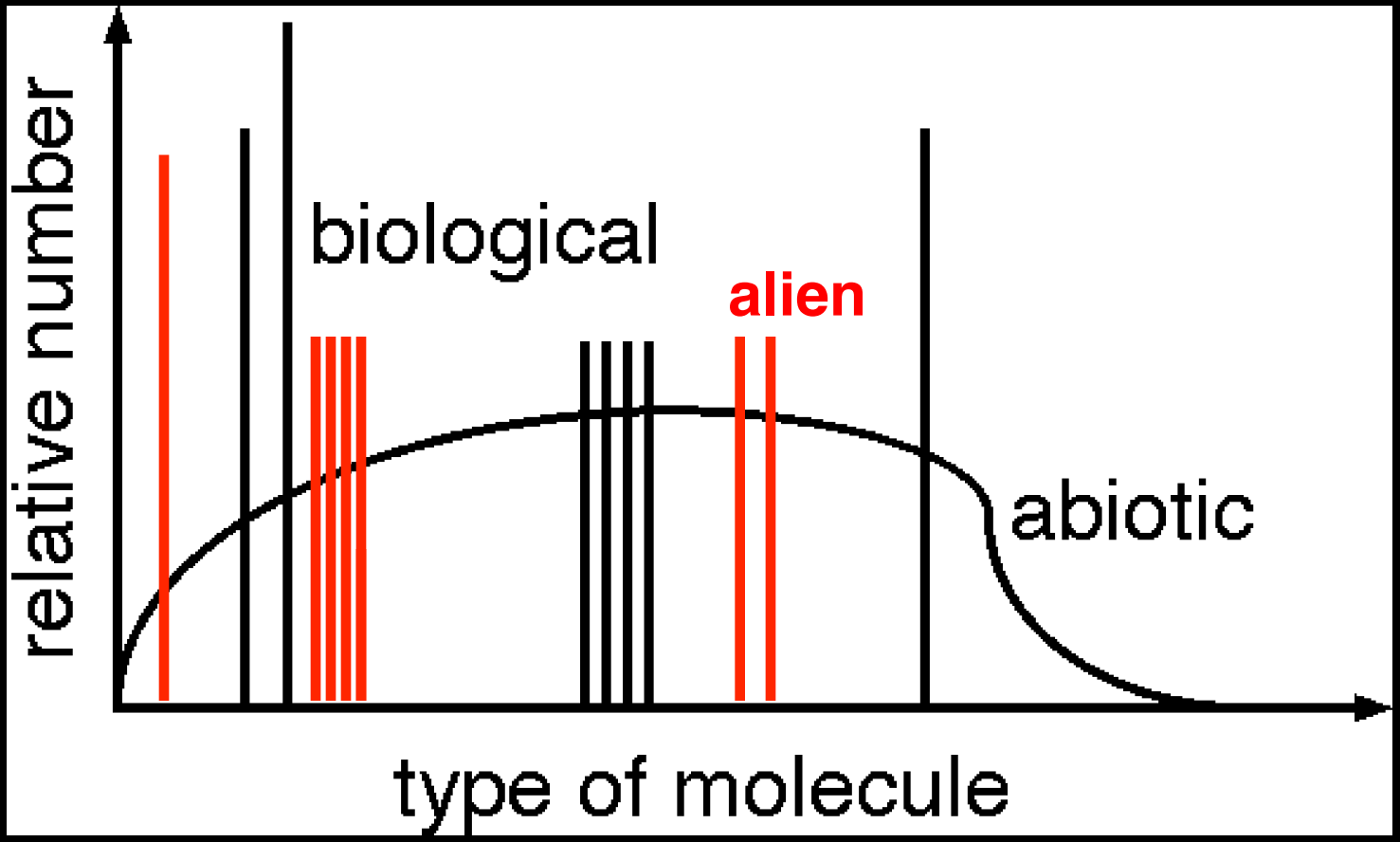

QUESTIONS?